

6. AMPÈRE'S DISCOVERY

Oersted's discovery in 1820 of the interaction between magnets and electric currents caused a sensation. The French astronomer Arago heard about it during his travels and related it in a meeting of the French Academy upon arrival. A week later his friend Ampère announced his discovery of the interaction between electric currents and his discovery of the electromagnet. As Maxwell has noted⁷¹, Ampère preferred to relate the Baconian rather than the true history of his discovery. My attempt to reconstruct the true history of the discovery makes use of the following historical material.

In his beautiful obituary notice on Ampère, Arago tells us⁷² that after Ampère had announced his discovery people said that it followed from Oersted's discovery: for if two currents interact with a magnet, they said, clearly they also interact with each other. This greatly annoyed Arago, who immediately pulled out of his pocket two keys and asked these same people whether they believed that since each of the two keys would interact with a magnet they would also interact with each other. This charming and thought-provoking story has not, to my knowledge, ever been discussed by

historians. Inasmuch as the anonymous people to whom Arago refers wished to belittle Ampère, there is indeed little point in trying to analyze what they have said. Inasmuch as what they have said may be considered as an historical explanation, I find it highly interesting and challenging, supportable by quotations from Ampère⁷³, and perhaps partly true. I cannot understand why historians have failed to take up this challenge. Here we have a situation where a man made a discovery a week after he had heard about a similar discovery. Evidently things are as closely connected here as one can ever expect them to be in the field of scientific development. What was the connection? What exactly was Oersted's influence on Ampère? Evidently, Ampère's discovery does not just follow from Oersted's discovery. But what assumption links them? And was that assumption new or a development out of old ones? And how did Ampère come to that assumption?

I suggest that perhaps Arago's adversaries were right on one point: Ampère did use the assumption that only likes interact (only gross matter acts on gross matter, only magnetic matter acts on magnetic matter, and the same for electricity, heat, etc.). But he used another assumption as well, which they overlooked.

The assumption that only likes interact is highly problematic, and, as Einstein has shown⁷⁴, it leads to essentially insoluble problems. But the amazing unanimity with which it once was held may be explained by showing how many problems it helped to solve. Take, for example, the one to which Arago was referring. As only likes interact, and as iron interacts with magnets, it must contain magnetic atoms. Why, then, does iron act on iron only in the presence of a magnet? This was answered by Coulomb's magnetic theory⁷⁵: there exist two magnetic fluids, north and south. A drop of each is present in each magnetic atom, and this explains why a piece broken off a magnet is itself a magnet. In a magnet the magnetic atoms are ordered in one direction; and, by Newton's law of addition of forces, the forces which they exert on another magnetic atom strengthen one another. In an iron bar, magnetic atoms are orientated in all directions and thus, by Newton's addition law, the forces they exert on another magnetic atom practically cancel each other out. When a magnet is present, the magnetic atoms in the iron bar reorientate and the bar becomes a temporary magnet. This theory of Coulomb explained a wide range of phenomena of magnetization and demagnetization.

Oersted seemingly refuted the law that only likes interact by finding that the magnetic needle of a compass is deflected in the presence of an electric current. He did not try to refute the law that only likes interact; rather (see below, section 7), he argued that electric forces and magnetic forces, and indeed all other forces, are likes; that essentially there exists only one kind of force. But this idea was too bold – or mad – to be considered even

for a moment. Even in the twentieth century, Oersted's chief biographer⁷⁶ and the editor of his *Works* chides him for his silly speculations (which influenced Faraday and Einstein). In any case, there is little doubt that Ampère had nothing to do with Oersted's speculations. Ignoring Oersted's idea of the essential identity of all forces, then, one seems to be bound to admit that Oersted refuted the hypothesis that only likes interact – unless, of course, either currents are really magnets or magnets are really currents. Ampère's brainwave was marvellously simple: the hypothesis that only likes interact can be reconciled with Oersted's discovery by assuming that magnets are really currents. Coulomb's atom of magnetism which contains a drop of north and a drop of south magnetic fluid has to be abolished; it should be replaced by small electric currents which run inside the magnet. Magnetic matter does not exist, and magnetic phenomena are all produced by electric currents. Thus, Ampère's hypothesis comes to rescue the hypothesis that only likes interact! Ampère's discovery of the interaction between currents and his discovery of the electromagnet follow logically from Ampère's explanation of Oersted's discovery, by his hypothesis of currents in iron plus the normal Newtonian assumptions about forces, moments (rotations), etc. As magnets are really currents, we must conclude that Oersted's discovery was the discovery of interactions between currents, although Oersted himself did not know it. This conclusion is not mine but Ampère's.

So much about Ampère's factual discovery. He did more than this, of course. Oersted thought that his own discovery, the deflection of the compass in the presence of a current, was caused by forces of rotation. Newtonian theory, however, denies the existence of rotational forces; it assumes the existence of forces which either pull or push; and it regards each enforced rotation as the result of a couple of forces acting in opposite directions (as a driver rotates his steering wheel by pulling and pushing it). Ampère explained the interaction between currents as a result of such forces. Yet even this was not orthodox enough. Newtonianism recognizes forces which depend on particles and their configuration (namely relative positions), but not on their motion. In order to render his theory more orthodox still, Ampère tried to make some hypotheses about the ether (the all-pervading thin elastic fluid) and the friction between the ether and the current. In this way he tried to explain the interaction between currents as forces depending on configurations rather than on motion.

Ampère, who was an admirer of Newton and an inductivist, thus opposed the method of speculations⁷⁷. The theories he used – that only likes interact and that all forces are pulls or pushes which do not depend on motion – were not mere hypotheses but were verified by experience. And what he added, particularly the theory that the atoms of magnetizable matter contain electric currents, he considered to have been verified. At the time, almost

everybody shared this view. But eleven years later, Faraday refuted Ampère's theory⁷⁸ and after a further fourteen years Weber claimed⁷⁹ that Ampère's error was due to his having speculated; namely, due to his not having followed the proper method of science. The connection between Ampère's errors and his discovery was then ignored: any connection between black and white must be purely accidental.